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(54) ULTRA CENTRIFUGAL CASCADE

(71) We, ALLMANNA SVENSKA ELEKTRISKA AKTIEBOLAG, a Swedish Company, of Västerås, Sweden, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a complete or partial ultra centrifugal cascade having a plurality of centrifuges in a common outer vessel.

Such cascades are already known (see British Patent Specification No. 893,647), but in the operation of these cascades it has proved difficult to achieve a stable construction of the various centrifuges disposed adjacent one another and to protect the various centrifuges disposed adjacent one another and to protect the various centrifuges against damage if an adjacent centrifuge breaks down, at the same time as avoiding complicated pipe-laying, etc., for transfer and cooling tubes.

The present invention aims to provide a solution of these and other similar problems and is characterised in that the rotors of at least some of the centrifuges are supported by common upper and lower perforated plates arranged inside the outer vessel.

Such a construction utilises the space inside the vessel to the full while at the same time providing satisfactory stability in relation to the vessel and between the centrifuges.

It is simple to arrange the centrifuges in groups with intermediate protection in the form of protective plates or rows of protective tubes, and the mutual configuration of the groups can be selected in many different ways without the need for reconstruction. The arrangement of the centrifuges in this way in a common vessel also means that the wall thickness of protective plates and the casing will be as great as the plate thickness which would be required to protect a single centrifuge and the arrangement accord-

ing to the invention also involves a considerable saving in material.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which

Figure 1 is a section through a centrifuge,

Figure 2 is a partly sectional view, on a reduced scale, of a cascade vessel,

Figures 3 to 5 are schematic sectional plans of the cascade of Figure 2, and

Figure 6 is a cascade connection diagram.

Figure 1 shows a single, vertical centrifuge which forms part of a cascade (see below). The centrifuge has a hollow rotor consisting of a cylindrical part 17 and two end pieces 15, 16 and 14, the rotor passing through the aperture in a perforated plate 36. The rotor is driven by an asynchronous motor having a rotor 12 and a stator 13, the stator having a casing part 18 mounted in a lower perforated plate 29.

The rotor 12 of the motor is supported by a bearing 19 and is connected to the end piece 14 of the hollow rotor of the centrifuge. Lubrication is provided by a lubricant storage space 20 and a lubricant wick 21 leading to the bearing 19. The upper and lower perforated plates 36, 29 are held together by concentric support pipes 32. The rotor of the centrifuge is journaled at its upper end in an electromagnetic bearing having a stator part 22 and a rotor part 11.

A gas or isotope mixture to be separated is introduced through a pipe 23 which may be an outlet pipe from a previous centrifuge or group of centrifuges in a cascade. The concentrated gas is removed through a conduit 24, the depleted gas is removed through a conduit 25. The gas is withdrawn through exhausts 27 and 28.

Figure 2 shows how a plurality of centrifuges 38, constructed like the centrifuge shown in Figure 1, are supported by common upper and lower perforated plates 36, 29 to provide a centrifugal cascade, the whole cascade being arranged inside a casing 37.

Figure 3 is a cross-sectional view of a centrifugal cascade having rows of protective tubes 40 which divide the centrifuges 41 into groups which are isolated from one another. With the centrifuges arranged in isolated groups, a breakdown of one centrifuge will not cause any damage except possibly to those centrifuges within the same limited group within the cascade, the others being protected by the rows of protective tubes 40. The rows of protective tubes may be replaced by protective plates. This means of protection gives the advantage that whereas a protection was previously required around each centrifuge, it is now sufficient to provide protection only at the outer walls of the vessel and/or between groups of centrifuges, which leads to a considerable saving in material.

Figure 6 is a flow diagram of an ultra centrifugal cascade in which an unseparated gas (or isotope mixture) containing U_{235} and 0.71% U_{235} is to be separated so that more concentrated U_{235} is obtained. In this diagram each of the squares represents a group of centrifuges, and the number within each square is the number of centrifuges in that group. The unseparated gas (or isotope mixture) is introduced at 42 and separated in fourteen centrifuges operating in parallel, after which the partially enriched gas mixture is fed in the enriching direction (upwards in Figure 6) to the next group in the cascade which has ten centrifuges operating in parallel. The number of centrifuges in this group is fewer because the quantity of gas is less. Depleted gas from the first group of centrifuges is led by a conduit 43 to the nearest preceding group of centrifuges where it is enriched again. At the end of the enriching process only one centrifuge is in operation, as can be seen, and the enriched gas contains 2.1% U_{235} . It will be seen that the depleted gas from all the groups of centrifuges is led to a preceding group of centrifuges in the cascade direction.

Depleted gas, containing 0.25% U_{235} is removed from the group of three centrifuges furthest away in the depletion direction.

Figure 4 shows a pipe system for the transfer of gas between the various cascade groups in an ultra centrifugal cascade operating in accordance with Figure 6. Natural uranium hexafluoride (UF_6) is supplied to the cascade at an inlet 44 and from here the gas mixture is introduced to common pipe conduits (main conduits) for several centrifuges within the same group. The various groups (see Figure 6) are designated 1-11 in Figure 4, one numeral denoting centrifuges belonging to the same group. The five centrifuges designated by the numeral 1 are located furthest away in the depleting

direction and the two centrifuges designated by numeral 11 are located in the corresponding enriching direction.

From the inlet 44 the gas is supplied to sixteen centrifuges operating in parallel and in the enriching direction the partially U_{235} enriched gas is taken out through conduits 46 and 47, the connection details of which are not shown. In this way all complicated pipe-laying using a large number of pipes is avoided, and all the pipes are located within the casing 37. This means that any leakage at pipe joints will only have any effect inside the cascade vessel.

Depleted gas is removed from group 1 at the outlet 48, and enriched gas is removed from group 11 at the outlet 49.

The cooling system is shown in Figures 1 and 5 and consists of a number of tubes 50 and 51 which run only in the upper and lower perforated plates 36, 29 (see Figures 1 and 2), and not along the length of the centrifuges between the perforated plates. The number of cooling systems is thus reduced to one per cascade instead of one per centrifuge.

Preferably only those centrifuges lying nearest the cascade inlet are provided with perforations (not shown) in the tubular wall of a tube 26 enclosing the pipe 23 and tubes 24 and 25. These perforations are provided to utilize the vacuum created outside the tube 26 in the centrifuge for evacuating the space around the pipe 23 and tubes 24 and 25. A pressure gauge is suitably introduced in the outer vessel to indicate if one or more of the centrifuges stops functioning. The reason is that a centrifuge unit which has stopped functioning gives greater leakage than one which is rotating. The upper perforated plate 36 has an aperture for each centrifuge unit 38, said aperture having a diameter slightly greater than that of the cylindrical part 17 of the centrifuge rotor. The stator 22 of the electro-magnetic bearing of the centrifuge is of greater diameter than said aperture and is firmly bolted to the upper side of the upper plate 36 (Figure 1). The holder for the stationary inner parts of the centrifuge unit is firmly bolted to the upper side of the perforated plate 36 or to the stator 22 of the magnetic bearing. The driving motor 12, 13 of the centrifuge unit, its casing part 18 and its bearing box are attached to the lower perforated plate 29 (Figure 1). The vertically positioned centrifuged units are suitably arranged in transverse, parallel rows (Figure 3) in the cascade vessels and are connected so that the centrifuge units in one and the same row process UF_6 having almost the same concentration. The collection conduits 46, 47 (see Figure 4 for UF_6 having approximately the same concentration are arranged in parallel with said rows. The shortest of said rows on one side of the cascade vessel

(11, Figure 4) comprises one or more centrifuge units which process UF_6 of the lowest concentration and a conduit from these units leads out through the wall of the cascade vessel to the outer main conduit for depleted uranium (conduit 49 in Figure 4). The short row (1) opposite said row (11) is connected in similar manner to the outer main conduit for enriched uranium (conduit 48 in Figure 4) and at least one of the long rows 3—8 positioned substantially centrally between said short rows comprises a number of centrifugal units which are connected by pipes 45 to the outer main conduit for the supply of UF_6 having the isotope content of the starting material.

WHAT WE CLAIM IS:—

1. An ultra centrifugal cascade having a plurality of centrifuges in a common outer vessel, in which the rotors of at least some of the centrifuges are supported by common upper and lower perforated plates arranged inside said outer vessel.

2. An ultra centrifugal cascade according to claim 1, in which drive members for said rotors are supported from one of said perforated plates.

3. An ultra centrifugal cascade according to claim 1 or 2, in which several centrifuges are connected together by transfer tubes which are enclosed in the outer vessel, completely above the upper perforated plate.

4. An ultra centrifugal cascade according to any of the preceding claims, in which the centrifuges are arranged in a number of groups, each group, except possibly the last one in the cascade, consisting of a plurality of parallel-connected centrifuges, greatest in number at an intake for a gas mixture to be separated, said groups being mutually cascade-connected and the number of centrifuges in each group decreasing in the enriching and depleting direction.

5. An ultra centrifugal cascade according to any of the preceding claims, in which sheet metal walls or rows of tubular protective elements are arranged between groups of centrifuges.

6. An ultra centrifugal cascade according to any of the preceding claims, in which conduits for supplying and withdrawing gas to and from each centrifuge are enclosed within a tube, only the, or each, tube enclosing conduits which supply and withdraw gas to and from a centrifuge, or centrifuges, located nearest the inlet of the cascade, being provided with perforations in its tubular wall.

7. An ultra centrifugal cascade according to any of the preceding claims, in which the upper perforated plate has an assembly aperture for each centrifuge, which aperture has a diameter slightly greater than the diameter of the rotor of the centrifuge.

8. An ultra centrifugal cascade accord-

ing to claim 7, in which a stator for a magnetic bearing for the centrifuge rotor has a greater diameter than said aperture and is firmly secured to the upper side of the upper perforated plate.

9. An ultra centrifugal cascade according to claim 8, in which a holder for the stationary inner parts of the centrifuge is firmly secured to the upper side of the upper perforated plate or to the nearest magnetic stator.

10. An ultra centrifugal cascade according to any of the preceding claims, in which the driving motor of each centrifuge, its casing and its bearing box are attached to said lower perforated plate.

11. An ultra centrifugal cascade according to any of the preceding claims for processing uranium hexafluoride, in which the vertically arranged centrifuges are placed in transverse, parallel rows in the cascade vessel and connected so that the centrifuges in one and the same row process uranium hexafluoride having almost the same degree of concentration.

12. An ultra centrifugal cascade according to claim 11, in which collecting tubes for uranium hexafluoride of substantially the same degree of concentration are arranged in parallel with said rows.

13. An ultra centrifugal cascade according to claims 11 and 12, in which the shortest of said rows at one side of the cascade vessel comprises one or more centrifuges which process uranium hexafluoride of the lowest concentration, a conduit from these centrifuges leading out through the wall of the cascade vessel to an outer main conduit for depleted uranium.

14. An ultra centrifugal cascade according to claim 13, in which the short row diametrically opposite said short row is connected in a similar manner to an outer main conduit for concentrated uranium, at least one of the long rows disposed between said short rows comprising a number of centrifuges which are connected via conduits to an outer main conduit for the supply of uranium hexafluoride having the isotope content of the starting material.

15. An ultra centrifugal cascade according to any one of the preceding claims, in which pressure gauges are fitted in the outer vessel to indicate if one or more of the centrifuges has stopped.

16. An ultra centrifugal cascade constructed and arranged substantially as herein described with reference to the accompanying drawings.

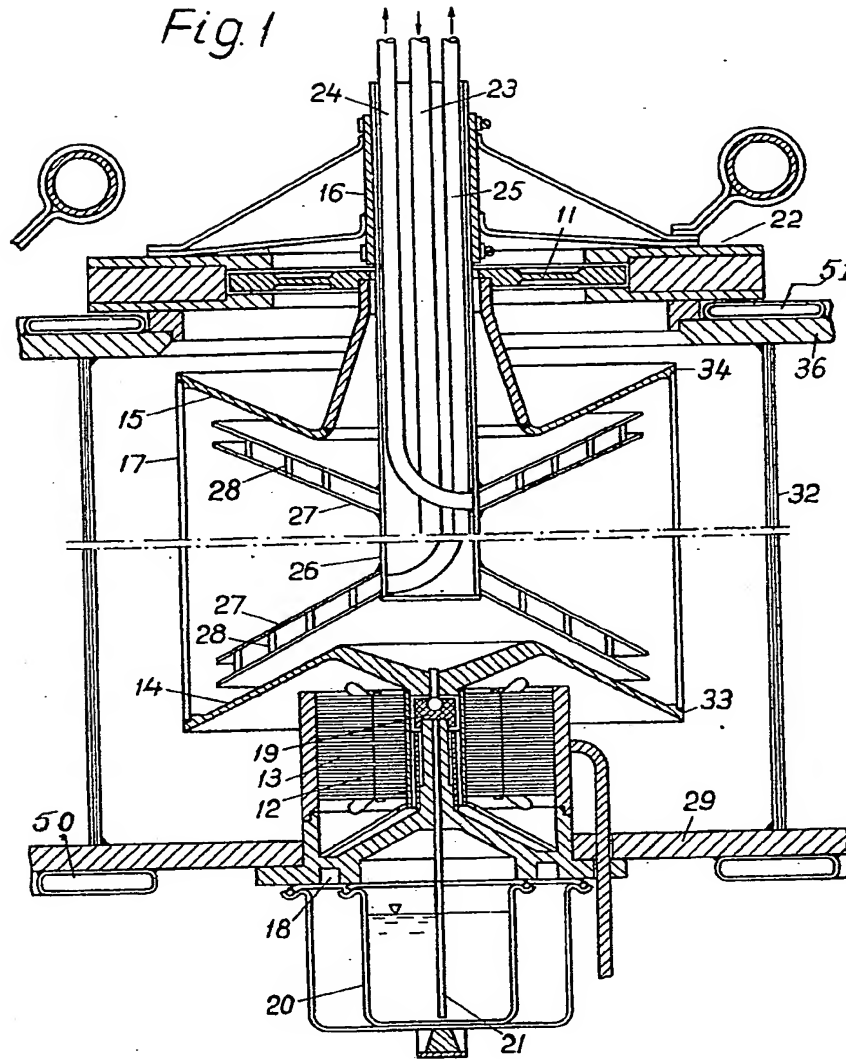
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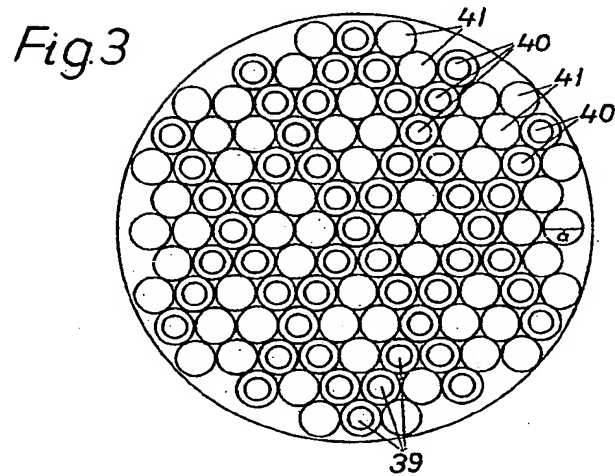
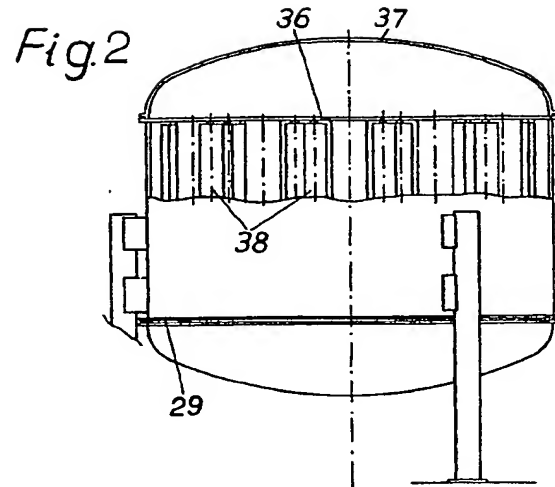
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Sheet 3

Fig.4

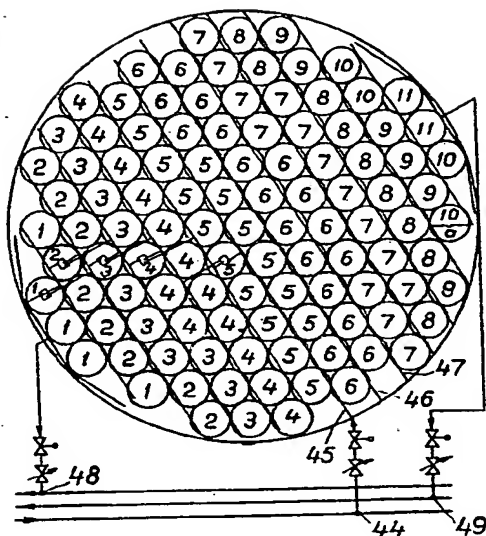


Fig.5

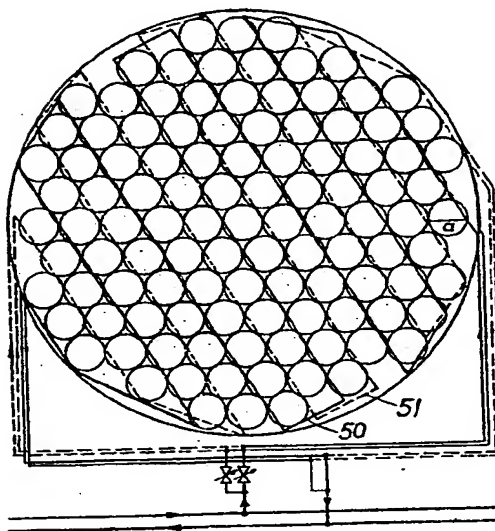
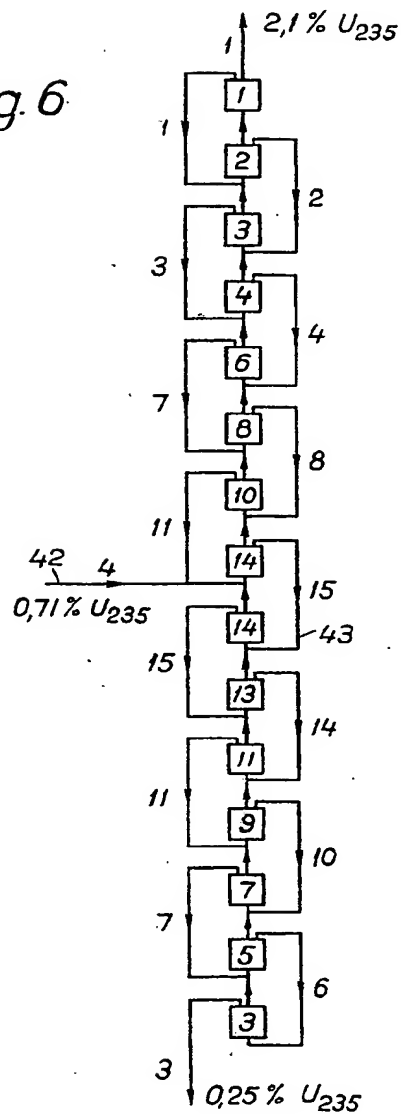


Fig. 6



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